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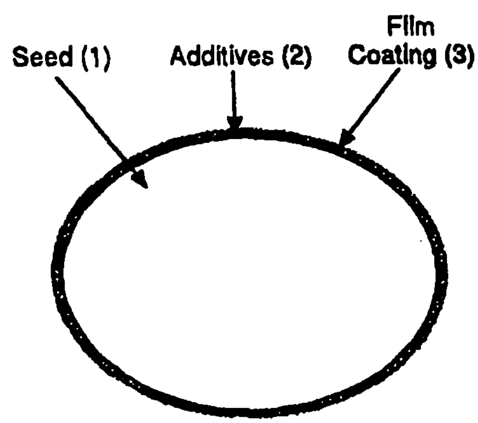

Schematic drawing of a seed film coated with a starch-based polymer containing additives.

(57) Abstract

A film coated seed is formed by film coating a seed with a starch–based, e.g., polysaccharide, water–dispersible or water–soluble polymer. The polysaccharide polymer is preferably produced by jet cooking the starch. One or more beneficial additives can be included in the film coating, including, for example only, adhesives or binders; plasticizers; colorants or dyes; hydrophobic and/or hydrophilic materials; insecticides, fungicides or herbicides; bacterial inoculants; nutrients; and plant growth regulators. The slurry treatment typically adds about 0.1 to 0.5 % by weight and film coating typically adds about 0.5 to 2 % weight to the seed. The low cost of a starch–based polymer makes film coating cost effective for a wide variety of seeds that have not been previously film coated.

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SEED FILM COATING WITH A STARCH-BASED POLYMER

Background of the Invention

1. Field of the Invention

The present invention relates to plant seeds, to plant seeds having a film coating thereon, and most particularly to the film coating of plant seeds with polymers containing polysaccharide or polysaccharide units, such as starch.

2. Background of the Art

The term "seed coating" has been used broadly in the seed industry to describe any process that adds materials to the seeds. There are, however, three distinct categories within the general class: seed coating, pelleting, and film coating. Seed coating, when used in its specific sense, generally refers to the addition of a layer of any material that would result in a significant weight gain and size increase, but where the coated seed retains the same shape of the uncoated (raw) seed. A typical example of the specific sense of seed coating is a coated alfalfa seed which results in a 50% weight gain from coating material. The coated seeds, however, still retain the kidney shape of an alfalfa seed. Pelleting is defined as the deposition of a layer of inert material that alters the original size and shape of the seed, resulting in significant weight increase and improved plantability. Regardless of the shape of the raw seed, the pelleted seed is almost always spherical or near spherical. The addition of biologicals, pesticides, fungicides, nutrients, repellants, colorants or dyes, and other beneficial ingredients may be included in either seed coating or pelleting compositions added to the seeds.

In contrast to seed coating and pelleting, which use an adhesive (binder) to adhere filler materials to the seeds to significantly increase the weight of the seeds, film coating applies a thin polymeric film over the seed coat. As expected, the film coated seeds retain the shape and size of the original seed with minimum weight gain. The primary purposes of film coating are agrochemical dust-off control, seed cosmetics, and seed variety identification. The film coating may also contain pesticides, fungicides, biologicals, identifying colorants

or dyes, and other additives. The coating is more or less a continuous coverage over the seed coat.

Seed coating, pelleting, and film coating have made great contributions to the seed industry. A significant number of agronomic, vegetable, and flower seeds are either coated, pelleted, or film coated today for diverse objectives. Seed coating can provide an opportunity to supply effective quantities of needed materials to each seed such that they can influence both the physical properties and microenvironment of the seed. These include protecting *Rhizobium,* providing a microenvironment for quick nodulation, insuring good seed-soil contact to improve movement of water to the seed, increasing seed weight and size to improve seed plantability, precisely loading seed treatment chemicals, supplying growth regulators, providing oxygen releasing compounds, adding beneficial elements to the seeds, and incorporating hydrophilic and/or hydrophobic materials to regulate seed water imbibation (the action of imbibing water or aqueous solutions) and germination.

Traditionally, seed treatment chemicals (including for example pesticides) have been either directly mixed with the seed in a dry state or applied to the seed in a slurry. Both dry and slurry methods result in considerable dust-off of the seed treatment chemicals, which not only is a waste of expensive seed treatment chemicals, but also is hazardous to the environment and to the people who treat, package, and plant the seeds. Film coating virtually eliminates dust-off and can provide a precise and uniform loading of the chemicals. This is particularly important when the chemical cost per seed is as high as that of the seed itself and the function of the chemical is rate dependent for disease and pest control.

Film coating can also offer other benefits to the seeds as well as to seed companies. It can protect the seed from mechanical damage during handling, reduce seed leakage and therefore reduce soil microbe attack to the seed, and significantly reduce waste disposal expense for the seed company if slurry treatment was used.

While film coating is highly advantageous, its application has been limited primarily to vegetable seeds and few field crops due to the cost of the polymers presently used. Film coating polymers on the market today are

primarily petroleum-based and cost about $5-$7 per solid pound. The cost of film coating is about 7¢ for each percent of weight gain per pound of seeds. Film coating of field crop seeds is not used on a large scale because the high cost of the polymer film and the degree of benefit do not justify its expense on low cost seeds. This is especially true for soybean seeds when the generic variety only sells for 30¢ per pound:

Polymer film coating with specialized functions can provide the seeds with additional physiological benefits. Cold imbibition damage (or imbibational chilling injury, that is, injury occurring after the seed has imbibed aqueous material under cool conditions or with subsequent exposure to cool conditions), a seed damage caused by quick water imbibition under cold soil conditions, has been considered one of the major factors preventing successful stand establishment of several crops, such as soybean, beans, cotton, and super sweet corn seeds. While the film coating polymers currently available on the seed market are mainly for agrochemical dust-off control, polymer film research should be directed towards the addition of other physiological benefits to the seeds, such as protecting the seeds from cold imbibition damage. A low cost polymer which adds such additional physiological benefits to the seeds would significantly increase the value of film coated seed and hence make film coating of low cost seeds more cost effective.

US Patent 4,729,190 to Lee shows membrane-forming polymeric systems which can be used for seed coatings. The polymeric system is a molecular association product of a polymeric carboxylic acid with an ethoxylated nonionic surfactant.

US Patent 3,698,133 to Schreiber shows a seed having a multilayered coating, which includes an inner coating of a particulate material and an outer coating of polymeric material.

US Patent 3,947,996 to Watts shows a seed coated with a polymer to control germination.

US Patent 3,947,996 to Watts shows a seed coated with a polymer to control germination.

US Patent 4,249,343 to Dannelly shows a seed coated with polymeric microgel particles.

Starch is a high molecular weight natural polymer, a polysaccharide, consisting of various portions of a linear polymer, amylose, and a branched chain polymer, amylopectin. Both of these components are composed of various portions of two glucose units. Starch is in a water-insoluble granule state at room temperature and becomes partially water-soluble or dispersible when heated to the gelatinization temperature. Even under those conditions it still contains many granules and so may be considered water dispersible rather than truly soluble. True solutions of starch in water may be produced by jet cooking, which pumps an aqueous starch slurry through an orifice where it contacts a jet of high pressure steam. The turbulence thus produced causes mechanical shearing of the starch and rupture of polysaccharide particles, leading to total and complete starch solubility in water.

Because of their unique polymer characteristics, native and processed starches have long been used in a broad range of applications, including some applications in the field of food use. Starches have also been used to some extent in seed coatings as a filler material.

U.S. Patents 5,318,635 and 5,571,552 to Kassica *et al.* disclose jet cooking of starch.

U.S. Patent 3,769,038 to Mitchell et al. shows a starch-fat composition for use in salad dressing and seasoning. The starch-fat composition is made by preparing an emulsion of water, fat and gelatinized starch, freezing the emulsion and freeze-drying the frozen emulsion.

U.S. Patent No. 5,676,994 and U.S. Patent Application Serial No. 08/806,134 to Eskens et al. shows an improved starch-oil composition, named Fantesk™, primarily for use in food products. The Fantesk™ is also described as being useful as a filler material in seed coatings to carry other active agents. Also described is a method of cooking starch to form a true starch polymer solution in water. The process comprises controlling the pH of the dispersion within a preferred range of 5-7; with the starch concentration in water between 2 and 40% by weight. The cooking is then performed in an excess-steam jet cooker under conditions which completely disrupt the starch granules and dissolve both the amylose and amylopectin. Some molecular breakdown of the starch is thought to occur.

U.S. Patent 4,812,445 to Eden et al. shows a starch-based encapsulation process in which virtually any material may be encapsulated in a starch matrix by combining the material with a high temperature stabilized dispersion of starch to form a gel. The starch gel is then sliced in the wet state, dried, and ground to yield particles containing the core materials within a shell of starch. The patent does not describe the use of cooked (e.g., jet cooked) starch polymer as an encapsulating polymer for seed film coating.

M.D. Jawson *et al.*, "*Bradyrhizobium japonicum* Survival in and Soybean Inoculation with Fluid Gels", Appl. Environ. Microbiol., Mar.1989, pp 617-622, describes the use of gels as carriers of the inoculant and for fluid drilling seeds. Grafted starch was one of the gel types tried.

P.M. Perkins-Veazie, "Improved Stand Establishment of Direct-Seeded Cabbage with Seed Covers," J. Amer. Soc. Hort. Sci. 114:36-39, 1989, shows some generally unsuccessful work in growth of germinated seeds in a starch-acrylamide-acrylate polymer gel.

US Patent 4,465,017 to Simmons shows a coated seed formed by first coating the seed with an adhesive and then a dry super absorbent chemical powder. The absorbent material is a starch graft polymer.

U.S. Patent 4,715,143 to Redenbaugh *et al.* is directed to a coated hydrogel capsule which contains meristemic tissue. The gel can contain starch and the capsule coating compounds can include starch acetate phthalate.

Summary of the Invention

The present invention describes a film coated seed wherein the film coating material comprises a polysaccharide starch coating. This coating preferably comprises at least 40% or at least 50% by weight of the polysaccharide starch as the film coating composition. It is preferred that the film coating material comprises jet cooked starch which comprises at least 40% or at least 50% by weight of the film coating composition.

The present invention describes a starch-based polymer for seed film coating. In the coated seed, the seed film coating comprises from 0.1 to 10% by weight of the seed (an added weight of 0.1 to 10% of the original seed weight). It is preferred that the weight gain of the seed is between 0.2 and 7%, more preferably between 0.4 and 5%, and most preferably between 0.5 and 3% of the

weight of the seed. The starch-based polymer may contain a variety of additives, especially at least one binder to improve the adhesive property of the polysaccharide to the seed, at least one plasticizer to improve the plasticity of the polymer, and a hydrophilic and/or hydrophobic material to regulate seed water imbibition and germination. Nutrients, growth regulators, pesticides, fungicides, herbicides, biologicals, identifying colorants or dyes, and other additives may also be included up to a maximum of 50% by weight of the seed coating, preferably between 1 to 30% by weight of the coating, more preferably between 5 and 20% by weight of the coating. The low cost of the starch-based polymer enables a greater variety of seeds to be film coated at an industry acceptable cost.

Brief Description of the Drawings

Fig. 1 is a cross-sectional view of a seed film coated with a starch-based polymer according to the invention.

Fig. 2 is a chart showing the improvement in germination percentage of black turtle and navy beans at a 2% buildup of the polymer film coating.

Fig. 3 is a graph showing the improvement in seedling field emergence of several bean varieties at 2% by weight build-up of the polymer film coating under a cold and wet soil condition.

Detailed Description of the Invention

Starch is a natural polysaccharide, a high molecular weight polymer comprised of repeating 1,4-α-D-glucopyranosyl units (AGU units) derived from plants and usually consist of various proportional mixtures of amylose (a linear-chained component) and amylopectin (a branch-chained component). Starch may be derived from various organic sources such as, but not limited to corn, peas, beans, rice, tubers (such as potato tapioca and arrowroot), cereal grains (such as wheat, milo, rye, and rice), and other plant forms, although usually in lower concentrations and lesser amylose content (as in cellulosic materials such as stalks, bark, chaff, wood pulp and the like) and is naturally present as discrete granules of from about 5 to 50 micrometers in diameter. Starch is available in various stages and forms, and after treatment can be considered a crystalline polymer, having crystalline regions or domains which must be disorganized to convert the crystalline polymer to an amorphous polymer which will then be dispersible or soluble in cold water (ambient temperatures of 5-25 ^{O}C).

Particularly suitable polymers are those which can develop a high viscosity liquid after dispersion in hot water. Suitable polysaccharide polymers include water-soluble or water-dispersible polysaccharides such as starches and gums. Particularly suitable polysaccharide polymers are described in U.S. Patent Nos. 5,318,635; 5,571,552; 5,188,674; and 4,812,445. These patents are herein incorporated by reference for their disclosure of useful starch based polymers and their methods of processing starches into solutions or dispersions, which solutions or dispersions can be used in the practice of the present invention to form film coating on seeds.

The seeds formed according to the present invention, as shown in Fig. 1, is a film coated seed, formed of a raw seed (1) with a film coating (3) adhering thereto. As noted above, the seed film coating comprises from 0.1 to 10% by weight of the seed (an added weight of 0.2 to 7% of the original seed weight). It is preferred that the weight gain of the seed is between 0.4 and 5%, more preferably between 0.5 and 4%, and most preferably between 0.5 and 3% of the weight of the seed. The film coating (3) may include other additive(s) (2) therein. The additive(s) (2) will generally be homogeneously distributed or dissolved in the film coating (3). The film coating (3) is generally a very thin, continuous film.

In accordance with the invention, film coating (3) is a starch-based polymer. Typically an adhesive or binder, such as polyvinyl alcohol (PVOH), polyvinyl pyrrolidone (PVP), or methylcellulose, will be included with the starch polymer in film coating (3). Plasticizers, surfactants, and thickeners are also included in the film coating (3) in traditional amounts (e.g., 0.1 to 15% by weight of the film coating material) to further improve the film forming properties.

Film coating (3) may also be loaded with a wide variety of other materials. Colorants or dyes can be included for variety identification and cosmetic purposes. Fungicides, insecticides, bactericides, fumigants, animal or insect repellants, rodenticides, larvacides, acaricides, molluscicides and herbicides can be added without dust-off problems. Bacterial inoculants, e.g., *Rhizobium* for nitrogen fixation, can be added at high concentration.

Hydrophilic or hydrophobic materials can be added to attract or repel water, respectively, to control seed water imbibition and germination. Macronutrients, such as nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S); micronutrients such as iron (Fe), boron (B), molybdenum (Mo), copper (Cu), manganese (Mn), Zinc (Zn) and chlorine (Cl); and beneficial mineral elements such as sodium (Na), silicon (Si), cobalt (Co), nickel (Ni), selenium (Se) and aluminum (Al) can be added as well as growth stimulants.

The polymer can be applied to the seeds by any convenient means and processes, such as, for example, both the conventional seed treater and CMS machine (produced by Coating Machinery Systems, Inc., Huxley, Iowa). The latter is the same coating apparatus used in the pharmaceutical industry.

The invention generally comprises a film coated seed comprising:

a) a seed, and

b) a film coating on said seed comprising a water-dispersible or water-soluble polysaccharide polymer. The film coated seed may further comprises from about 0.1 to about 10% by weight of the seed, and said polysaccharide polymer preferably comprises jet-cooked starch. The film coated seed more preferably comprises from about 0.1 to about 5% by weight of the seed. It is still more preferred where said film coating composition comprises at least 50% by weight of said polysaccharide polymer. The at least one additive is preferably selected from the group consisting of adhesives or binders other than said polysaccharide polymer, plasticizers, colorants, insecticides, fungicides, herbicides, surfactants, starch catalyzing enzyme, inoculants, macronutrients, micronutrients, drying agents, preservatives, and plant growth regulators. Other ingredients such as crosslinking agents for the starch-based polymer, hydrophilic agents, and hydrophobic agents may also be added to adjust the physical properties of the starch-based polymer film coating on the seed. Other biologically active ingredients known in the agricultural field, such as repellants, pheromones, attractants, stabilizing agents (especially for specific ingredients contained within the coating composition), antioxidants and the like may also be present within the coating composition or within additional coatings.

The film coated seed with the water-dispersible or water-soluble polysaccharide polymer of said film coating is more easily metabolized by an embryo from said seed than internal starch in said seed.

A method for increasing the germination rate of a seed comprises coating a slurry of a water-dispersible or water-soluble polysaccharide polymer onto a seed, and then drying said slurry to form a film coating which weighs from about 0.1% to 10% by weight of said seed. It is especially desirable where the film coated seed has a film coating which comprises a continuous film on the surface of said seed. By a continuous coating, at least 90%, and preferably at least 95% to 100% of the surface of the seed is covered by the polymeric film coating. It is also preferred that the additives to the starch-based polymer, such as the adhesive (e.g., a synthetic organic polymer which increases the adhesion of the film coating to the seed as compared to a film coating without said polymer present), comprises from 0.1 to 25% by weight of the total dry coating composition or by weight of the starch-based polymer.

The method of forming a film coated seed according to the present invention may also be described as comprising the steps of forming a slurry comprising a water-dispersible or water-soluble polysaccharide polymer, applying the slurry to the surface of a seed, and drying said slurry to form a film coating comprising from 0.1 to 10% by weight of said seed. The additives suggested above may be present during cooking (e.g., jet cooking) of the starch if they are not too degradated by the cooking process, or may be added to the slurry.

The starch polymer may be prepared by any conventional or advanced process which is able to provide a polysaccharide polymer. The polymer is able to provide the minimum physical characteristics needed in the coating. The preferred minimum characteristics include combinations of film forming ability (so that a continuous film coating may be provided), cold water dipsersibility or solubility, and sufficient film strength that the coating is not readily removed by abrasion from other coated seeds during transportation and handling. The polysaccharide polymers may be pre-gelatinized or gelatinized starches. The gelatinized starches can be used in the slurry state or by reconstitution of the dry

powder in water, but are more preferably used in the slurry state right after jet cooking. The dry powder of pregelatinized starches is typically prepared by spray-drying, drum drying or extrusion of a starch slurry or paste. Drum drying and extrusion of the starch slurries are the less preferred methods of preparation because of the poorer dispersing of the starch particulates, but they are both useful within the scope of the present invention. Spray drying, as taught in U.S. Patent Nos. 5,318,635; 5,571,552; and 5,188,674 is the preferred method of providing the polysaccharide for use in the film coating compositions of the present invention.

Many variations within the treatment process of the starch are acceptable in the practice of the present invention, even some which would not be acceptable if the product were being used directly for human consumption. For example, acid treatment of the starch, to produce a "modified" starch during the spray drying (or other) process of preparation may be performed. Ambient drying (e.g., air drying), forced air drying, infrared drying, oven drying and the like may speed the formation process for the film coating compositions. High pressures (e.g., 2,000-10,000 psi) under steam, autoclaving, cooking chambers and the like may be used to speed any cooking processes used to form the highly dispersed polysaccharides of the present invention.

The composition of the polymer (especially with respect to its relative amylose and amylopectin ratios) may be selected according to the specific characteristics desired by the ultimate user. It is possible to purify the available starches to essentially 100% of either polysaccharide (the amylose and amylopectin), but this would tend to be prohibitively expensive, although the convenient preparation of 100% amylose from potato starch has been indicated in the literature (e.g., U.S. Patent No. 5,318,635, column 10, lines 13-17). More properly, the original polysaccharide source is chosen for its amylose and amylopectin ratio, and the process may be adjusted by conventional means (e.g., U.S. Patent Nos. 3,607,394 and 5,318,635) to work with the various different properties that the differing ratios provide. It is usual that the available starches will have ratios of amylose and amylopectin between 10:90 and 90:10, more often between 25:75 and 75:25, and still more often between 60:40 and 40:60.

The starches may be cooked in conventional commercial equipment such as that available from Avebe (Holland), National Starch and Chemical Corp. (USA) and Roquette Freres (France). The starch-based polymer, as previously noted may be made by any convenient process, and any spray-drying equipment which produces a suitably dispersed particulate which can be reconstituted in water to coat the seeds may be used. Complexing agents, gums (e.g., polysaccharide gums, oils, surfactants, acids, derivitizing agents and the like may be added to the slurry, preferably in most cases after cooking, but also as a co-cooked additive in the preparation of the cooked polymer.

A typical basic process for preparation of a film coating composition of the present invention could include the following types of preparation procedures. An unmodified, granular corn starch (e.g., with or without high amylose content) would be slurried in water and cooked in a jet cooker. Steam (at, for example, between 130 and 160 psig) would be used to cook the starch. The heated, cooked starch is now ready to be mixed with other synthetic polymers or ingredients to make a film coating composition. When dry powder is preferred, it would be conveyed at elevated temperatures near the cooking temperatures to a spray dryer. Compressed air would atomize the starch slurry (e.g., at 1-30% solids content), which would then be dried (either in the air sprayed step or subsequently after collection). The resulting powders could then be recovered in a cyclone separator. A pneumatic atomization nozzle could alternatively be used, especially with higher solids content (20-45%) in the slurry. Traditional cooking temperatures in the field would be used, preferably within the range of 120°C to 160°C. Cooking times may vary as needed for the particular slurries and materials, as from about ten minutes to an hour or more.

As noted previously, other ingredients such as the adhesive or binder may be either co-cooked with the starch slurry to form the starch-based polymer slurry or added later. The slurry can be prepared at a higher concentration and then diluted later with water before use, or the dried particulates may be later reconstituted in water. The film coating polymer may applied to the seeds while the seeds are tumbling in a coating machine by spraying a fine mist of the polymer through a nozzle of a spray gun, or the seeds may be directly mixed with the polymer in a conventional slurry seed treater.

According to the present invention, an improved low cost polymer is provided which makes film coating of virtually all seeds economically viable and produces significant results in seed performance. As shown in Fig. 2, the germination percentage of two bean species, black turtle and navy beans film coated with the polymer at 2% buildup, was compared with the uncoated control. The cold test protocol was 5 days at 5°C, 5 days at 15°C, and 8 days at 25°C. The film coating, designed to slow down water imbibition by the seed, contained co-cooked starch, PVOH and rosin (binders), urea (plasticizer), a hydrophobic material (wax), a cross linker to strengthen the starch, and a colorant. The germination percentages of the film coated seeds were 28% and 24.5% higher than the uncoated control for black turtle and navy beans, respectively.

The benefits of the practice of the present invention were further shown using additional types of dry bean seeds when 2% film coated seeds were compared with uncoated controls. The data is shown in Figure 3. Under a cold and wet soil condition, the field emergence percentage of three cold sensitive varieties (navy beans, green baby lima beans and white kidney beans) with a 2% by weight film coating of jet-cooked, polysaccharide polymeric composition were 29.4%, 18.3% and 11% higher than their uncoated controls, respectively. It should be apparent that the higher rate of field emergence is a significant economic advantage to the farmer.

Since the cost of a starch-based polymer is much lower than conventional polymers used to film coat seeds, the added cost per pound of seed is also very low. For example, using a starch-based, polysaccharide polymer costing about one dollar per pound, the added cost of coatings is about $0.01 per percent buildup, as compared to the $0.07 per percent buildup with petroleum-based polymers. This makes the economical film coating of low cost seeds possible. The polysaccharides also can be metabolized by the seed embryo, and may even be metabolized more rapidly by the seed embryo than the endosperm. This type of coating can therefore be more nutritional for the seed (than petroleum-based polymer coatings), even without the addition of nutrients to the polymer. The starch based, polysaccharide polymer is biodegradable, compatible with most of the commercially available additives which have been listed as optionally included within the film coatings of the present invention, and can be used on

virtually any seed as a film coating. This includes agronomic seeds, vegetable seeds, grass seeds, flower seeds, tree seeds and shrub seeds. The film coatings may even be added to coated seeds as an additional protective coating. The following is an exemplary, but not exclusive list of some seeds which have been test film coated with starch-based polymers in accordance with the invention. These seeds include corn (including field corn and *sh2* corn), soybeans, sunflowers, sugar beets, canola, cucumber, coated alfalfa and grass.

The starch-based, polysaccharide polymer can be used either as a core polymer for continuous coating or as an agent for dust-off control of slurry treated seeds. When the film coating is described as a continuous film, it is meant that there are not significant uncoated areas of the seed (e.g., less than 3% uncoated). The water-soluble or water-dispersible starch usually must comprises the major component (at least 50% by weight) of the film coating material. An adhesive or binding agent (preferably comprising a synthetic polymer, preferably a synthetic hydrocarbon (including O and N atoms, such as in acrylates, acetates, epoxy resins, polyoxyalkylene resins, polyvinyl alcohol, polyvinylpyrollidone, and natural gums and resins) which increase the adherence of the starch to the seed surface, increase its flexibility, reduce its brittleness, and/or add luster to the appearance of the film are preferred in amounts of from 0.1 to 25% by weight of the starch polymer, preferably between 0.5 and 10% by weight of the starch polymer. When the polymer is used as a dust-off control agent for slurry treated seeds, the amount of the polymer used is preferably just enough to show significant reduction of chemical dust-off, and is usually provided as several ounces (58-120 grams) of slurry per hundred pounds (45.5 kg) of seeds (equivalent to about 0.1 to 0.5% by weight of the seed).

The particulate starch based polymer which is formed by a physical change in the size of the original particles opposed to a chemical change in the starch material which is caused by chemical treatments. The recited particulate starch polymers of the present invention tend to have approximately the same molecular weight as the original starch material, as opposed to the chemically treated polysaccharide materials which are broken down and then polymerized. In addition to this distinguishing characteristic, the prior art may be further individually distinguished for at least the following reasons:

U.S. Patent No. 4,495,724 is a copolymer of starch and acrylonitrile (for example) and is not water-soluble as is claimed in the present invention for the coating polymers. The claim language of "water-soluble or water-dispersible" clearly distinguishes the fundamental nature of these polymers and their function on the seed. This reference cannot support a rejection under 35 U.S.C. 102(b) not provide a reasonable basis for suggesting obviousness under 35 U.S.C. 103.

U.S. Patent No. 3,935,099 similarly does not disclose a water-soluble or water-dispersible starch polymer. The purpose of the coating in this reference is to remain on the surface of the seed and to absorb water. That is merely hydrophilic, not water-dispersible. If the coating were water-dispersible, it would break down in contact with water which is undesirable in the performance of the function of this reference. U.S. Patent No. 4,251,952 also clearly requires a water-insoluble film coating.

U.S. Patent No. 5,328,942 is clearly limited to cellulosic polymers, which are excluded by the description of particulate starch polysaccharide polymers recited in all claims of the application.

The presently claimed coating is a starch polymer, not a chemically modified hydrolyzate of chemically treated starch. The starch particles are mechanically treated to reduce their size without any significant chemical treatment reducing their molecular weight, chemically modifying them or the like. The polymers are formed from actual particles of starch having substantially the same molecular weight as the original starch particles, but differing in weight. The use of such a material as seed coatings is novel.

The present invention does not include the use of polysaccharide derivative hydrolyzates as coatings of seeds. In that type of process, polysaccharides are produced by enzymatic degradation. This is clearly a chemical treatment of starch which alters the chemical nature of the material and does not produce starch particles, but a starch hydrolyzate composition. The molecular weight of the polysaccharide is greatly reduced. In addition, the polysaccharides are derivatized with groups such as carboxymethyl, methyl hydroxypropyl, etc.

In the present invention, starch granules are ruptured by passing them through an orifice under high pressure and temperature. Their physical size is

reduced, but the starch molecules and their molecular weight are not altered. This is a physical reaction as compared to the chemical reaction of starch hydrolyzate formation.

The prior art clearly fails to teach one of ordinary skill in the art to even consider the use of such a starch polymer (as opposed to a starch-derivatized polymer) as a seed coating. The absence of the need for chemical alteration of the starch, the lower costs involved, and the simplicity of polymer formation are clear advantages not considered in the art of record.

Changes and modifications in the specifically described embodiments can be carried out without departing from the scope of the invention which is intended to be limited only by the scope of the appropriate claims.

WHAT IS CLAIMED:

1. A film coated seed comprising:

a) a seed, and

b) a film coating on said seed comprising a water-dispersible or water-soluble particulate starch polysaccharide polymer.

2. The film coated seed of claim 1 wherein said film coating comprises from about 0.1 to about 10% by weight of the seed, and said particulate starch polysaccharide polymer comprises jet-cooked starch.

3. The film coated seed of claim 1 wherein said film coating comprises from about 0.1 to about 5% by weight of the seed.

4. The film coated seed of claim 2 wherein said film coating composition comprises at least 50% by weight of said particulate starch polysaccharide polymer.

5. The film coated seed of claim 3 wherein said film coating composition comprises at least 50% by weight of said particulate starch polysaccharide polymer.

6. The film coated seed of claim 1 wherein said film coating comprises at least one additive selected from the group consisting of adhesives or binders other than said particulate starch polysaccharide polymer, plasticizers, colorants, insecticides, fungicides, herbicides, surfactants, starch catalyzing enzyme, inoculants, macronutrients, micronutrients, and plant growth regulators.

7. The film coated seed of claim 5 wherein said film coating comprises at least one additive selected from the group consisting of adhesives or binders other than said particulate starch polysaccharide polymer, plasticizers, colorants, insecticides, fungicides, herbicides, surfactants, inoculants, macronutrients, micronutrients, and plant growth regulators.

8. A film coated seed comprising:

a) a seed, and

b) a film coating on said seed consisting essentially of a water-dispersible or water-soluble particulate starch polysaccharide polymer and at least one additive selected from the group consisting of adhesives or binders other than said particulate starch polysaccharide polymer, plasticizers, colorants, insecticides, fungicides, herbicides, surfactants, inoculants, macronutrients, micronutrients, starch catalyzing enzymes and plant growth regulators.

9. The film coated seed of claim 8 wherein said film coating comprises from about 0.1 to about 10% by weight of the seed.

10. The film coated seed of claim 8 wherein said film coating comprises from about 0.3 to about 5% by weight of the seed.

11. The film coated seed of claim 9 wherein said film coating composition comprises at least 50% by weight of said particulate starch polysaccharide polymer.

12. The film coated seed of claim 10 wherein said film coating composition comprises at least 50% by weight of said particulate starch polysaccharide polymer.

13. The film coated seed of claim 1 wherein said water-dispersible or water-soluble particulate starch polysaccharide polymer of said film coating is more easily metabolized by an embryo from said seed than internal starch in said seed.

14. A method for increasing the germination rate of a seed comprising coating a slurry of a water-dispersible or water-soluble particulate starch polysaccharide polymer onto a seed, and then drying said slurry to form a film coating which weighs from about 0.1% to 10% by weight of said seed.

15. The method of claim 14 wherein said film coating comprises from about 0.3 to about 5% by weight of the seed and said film coating comprises at least 50% by weight of said particulate starch polysaccharide polymer.

16. The film coated seed of claim 12 wherein said film coating comprises a continuous film on the surface of said seed.

17. The method of claim 15 wherein said film coating is dried to form a continuous coating around said seed.

18. The film coated seed of claim 2 wherein said film coating comprises from 0.1 to 25% by weight of an adhesive.

19. The film coated seed of claim 2 wherein said film coating comprises from 0.1 to 25% by weight of a synthetic organic polymer.

20. The film coated seed of claim 2 wherein said film coating comprises from 0.1 to 25% by weight of a synthetic organic polymer which increases the adhesion of the film coating to the seed as compared to a film coating without said polymer present.

21. A film coated seed comprising:

a) a seed, and

b) a film coating on said seed consisting essentially of a water-dispersible or water-soluble particulate starch polysaccharide polymer, said film coating comprising from 0.1 to 5% by weight of said seed.

22. The film coated seed of claim 1 wherein said film coating comprises a water-dispersible or water-soluble particulate starch polysaccharide polymer and at least one additive selected from the group consisting of a crosslinking agent for said water-soluble particulate starch polysaccharide polymer, a hydrophilic agent and a hydrophobic agent.

23. A method of forming a film coated seed comprising the steps of forming a slurry comprising a water-dispersible or water-soluble particulate starch polysaccharide polymer, applying the slurry to the surface of a seed, and drying said slurry to form a film coating comprising from 0.1 to 10% by weight of said seed.

24. The process of claim 23 wherein said slurry comprises a water-dispersible or water-soluble particulate starch polysaccharide polymer and at least one additive selected from the group consisting of:

adhesives or binders other than said particulate starch polysaccharide polymer,

plasticizers,
colorants,
opacifying agent,
insecticides,
fungicides,
herbicides,
surfactants,
inoculants,
macronutrients,
micronutrients,
drying agents,
preservatives,
starch catalyzing enzymes and
plant growth regulators.

25. The process of claim 23 wherein said slurry comprises a water-dispersible or water-soluble particulate starch polysaccharide polymer and at least one additive selected from the group consisting of a crosslinking agent for said water-soluble particulate starch polysaccharide polymer, a hydrophilic agent and a hydrophobic agent.

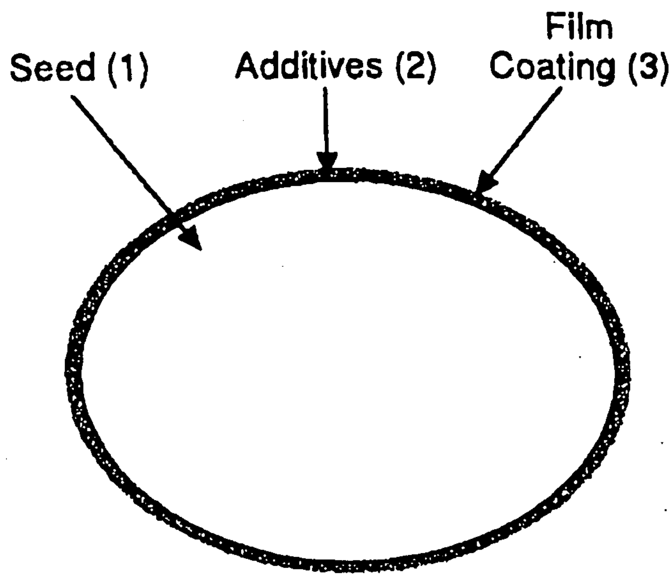

Figure 1. Schematic drawing of a seed film coated with a starch-based polymer containing additives.

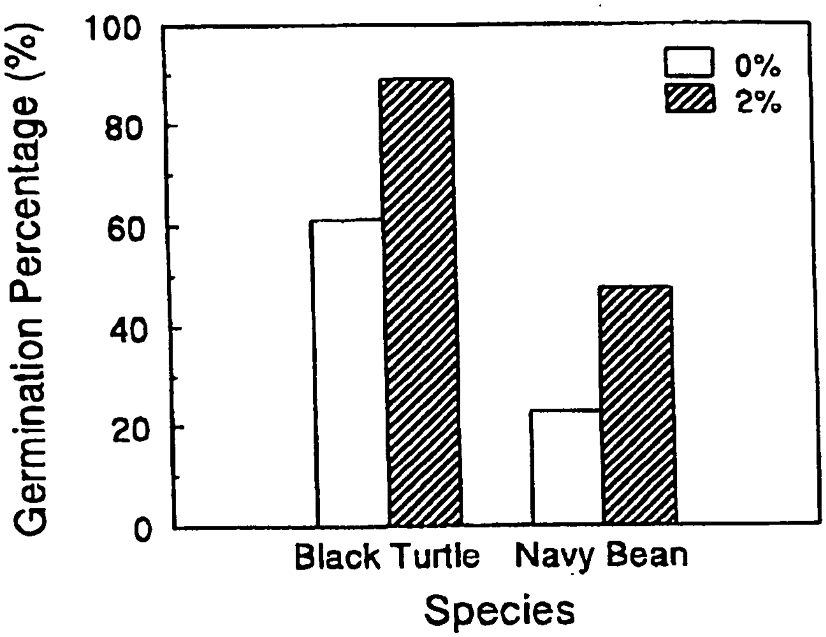

Figure 2. Cold test (5 d @ 5 °C, 5d @ 15 °C, 8d @ 25 °C) of bean seeds film coated at 2% buildup with a starch-based polymer containing a hydrophobic material.

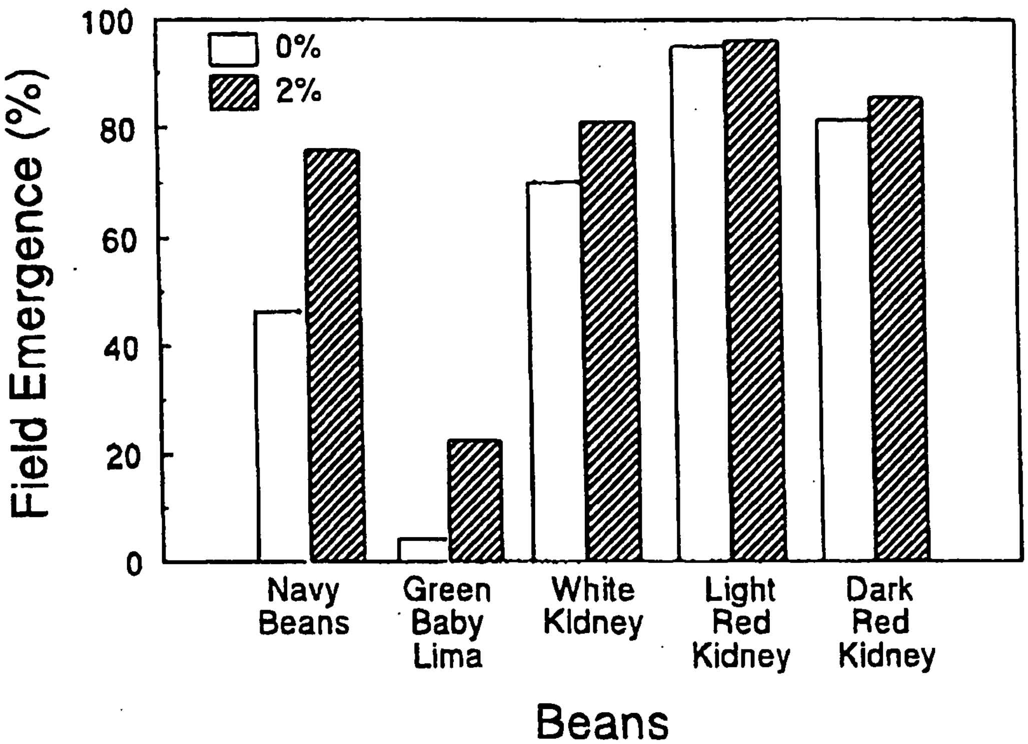

Figure 3. Field emergence test of bean seeds film coated at 2% buildup with a starch-based polymer containing a hydrophobic material. The tests were conducted in Wisconsin in the Spring when the soil was cold and wet.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/10753

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A01C1/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 750 466 A (WEDEGAERTNER THOMAS C ET AL) 12 May 1998 (1998-05-12) claims 1,6,7,13	1,3,5-25
A	US 5 676 994 A (ESKINS KENNETH ET AL) 14 October 1997 (1997-10-14) cited in the application column 2, line 9 - line 15 column 12, line 1 - line 5	1-25
A	WO 93 25078 A (ALKO AB OY ;KOISTINEN TARJA (FI)) 23 December 1993 (1993-12-23) claims	1-25

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 August 1999	02/09/1999

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US 99/10753

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